ONE POSSIBLE ALTERNATIVE WAY IN PLANT NUTRITION – FLUID BY-PRODUCT OF BIOGAS FACTORY

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Abstract: One of the most important expectations regarding sustainable agriculture is the minimization of the use of industrial chemicals while affording producers with the ability to produce at the same level. One possibility to minimize chemicals is the use of the by-products of biogas factories. By using fluid by-products of biogas factory, we are able to decrease amounts of chemical fertilizers. Crop plants extract huge amounts of nutrients from soils. In order to get the same yield – in quality and quantity- it is necessary to replace the extracted minerals that were harvested by plants with nutrients. Fluid by-products contain several essential elements; therefore, it can be suitable material to substitute industrial chemicals.
The physiological effects of fluid by-products originating from a biogas factory located in Biharnagybajom (Eastern-Hungary) were examined. The experimental plant was *Zea mays L*. Eight different concentrations of fluid by-product were examined during the experiment.. The following basic plant physiological parameters were measured: dry matter of shoots and roots, relative chlorophyll contents (SPAD-Units) and uptaken element in the shoots and roots in nutrient solution experiment.
By the examination of several physiological parameters we came to the conclusion that the fluid by-product of biogas factory can be suitable material to replace the industrial chemicals, especially in bio-production.

Keywords: crop production, nutrient solution, fluid by-product, maize, soil

Introduction

The most important questions today – „how much more can the Earth take?” and „how can we ensure sustainability?”. Nowadays the fossil energy sources are limited. Todays, agricultural research is focused on sustainability in production., in using renewable sources and protecting the environment. One of the big problems is the use of chemicals in agriculture. The useage of chemicals has a harmful effect on the environment and human health. It is necessary to avoid the useage of mineral fertilizers. One of the ways of doing this is to use manure complemented with a fluid by-product of biogas.
The biogas is originated from different ambience for example wastewater sludge, dump, (Wellinger and Linberg, 2000) animal manure, agricultural waste, kitchen waste and alga (Arthur et al., 2011). The biogas from wastewater sludge contained 55-60% methane, 35-45% carbon-dioxide and 1% nitrogen (Allen et al., 1997) and biogas from organic waste contained 60-70% methane, 30-40% carbon-dioxide and 1% nitrogen (Eklund et al., 1998).

Materials and methods

Maize (*Zea mays* L. cv. Norma) was used in these experiments. The seeds were soaked in 10 mM $CaSO_4$ for 4 hours after sterilization and then germinated on moistened filter paper at 22 ^{o}C. The seedlings were transferred to continuously aerated nutrient solution of the following composition: 2.0 mM $Ca(NO_3)_2$, 0.7 mM K_2SO_4, 0.5 mM $MgSO_4$, 0.1

mM KH_2PO_4, 0.1 mM KCl, 1µM H_3BO_3, 1µM $MnSO_4$, 10 µM $ZnSO_4$, 0.25 µM $CuSO_4$, 0.01 µM $(NH_4)_6Mo_7O_{24}$. Iron was added to the nutrient solution as Fe(III)-EDTA at a concentration of 100 µM.
The seedlings were grown under controlled environmental conditions (light/dark regime 10/14 h at 24/20 °C, relative humidity of 65–70 % and a photosynthetic photon flux of 300 µmol m^{-2} s^{-1}).
The applied fluid by-product of biogas factory is originated from the biogas industry of Biharnagybajom. The following treatments were applied during the examination: control (nutrient solution without by-product), 5 ml dm^{-3}, 10 ml dm^{-3} and 50 ml dm^{-3} from by-product.
The relative chlorophyll content was measured on the second and third leaves. The relative chlorophyll content was measured with SPAD-502 (MINOLTA, Japan) Chlorophyll Meter. The plant samples were dried at 85 º C for weight permanence and were measured with analytical scale (OHAUS) after cooling back them to room temperature. The uptake of the elements was measured by ICP.
For the statistical evaluation Microsoft Excel 2003 and Sigma Plot 8.0 version were used.

Results and discussion

The examined by-product contains plenty of useful elements, for example K, Mg, P, S and Ca, but it also contains considerable toxic elements, for example Cd, Cr and Al (Table 1.).

Table 1. Contents of examined elements (Al, Cd, Cr, Ni, Sr, Ca, Fe, K, Mg, P) in fluid by-product of biogas factory (mg kg^{-1})

Toxic elements					Essential elements				
Al	Cd	Cr	Ni	Sr	Ca	Fe	K	Mg	P
109	0.12	0.39	<1	6.4	1,411	157	2,651	433	448

Mg has a major function, because it is role as the central atom of chlorophyll molecule. Potassium is a cation that appears in the largest quantities in plants. Potassium plays a very important role e.g. in the frost tolerance of plants (Wyn Jones et al., 1979). Other important elements include magnesium. In green leaves, a major function of magnesium, and certainly its most wide-known function, is its role as the central atom of the chlorophyll molecule (Michael, 1941).
The effect of any nutrients can be considered directly, when the plants take it up, and the element gets into the living cell. Then the elements will be transferred to the different part of plant. The tolerant plants exclude the harmful elements from their metabolism, through the excretion of the elements to the vacuole. The sensitive plants are not able to transfer these elements from the roots, therefore these accumulate, causing the changing of membrane functions, and also effect on osmotic potential. The concentrations of examined elements in the shoots and roots of corn can be seen in Table 2. treated by fluid by-product of biogas factory.

Table 2. Elements content (Ca, K, Mg, P, S) in the shoots and roots of maize effected by different treatments (mg kg^{-1})

The examined elements in the shoot of maize				
Elements	Treatments			
	Control	5 ml	10 ml	50 ml
Ca	6842	5689	6017	3541
K	77070	58265	62382	45159
Mg	1958	2149	2429	2210
P	16410	14721	16764	10766
S	3059	3416	4016	3903
The examined elements in the root of maize				
Elements	Control	5 ml	10 ml	50 ml
Ca	3584	5982	7189	5555
K	19078	30306	13418	8341
Mg	1814	2374	1577	1154
P	3897	6794	5229	5079
S	4058	7151	5375	5951

The concentration of Ca, K and P decreased at the 50 ml treatments in the shoots compared to the control. The content of S increased at all treatments. The concentration of Ca, P and S increased in the roots in all treatments compared to the control. The elements can influence the growth of root and shoot depending on the accumulation efficiency. The dry matter content of shoots and roots of sunflower were also during the experiments. Table 3. shows the results of dry matter accumulation.

Decrease of dry matter of roots and shoots was observed at the all treatments compared to the control. The decreasing was significant in the shoots at the 10 ml treatment, and in the roots at the 5 and 50 ml treatments.

The decreasing dry matter accumulation can be explained by the lower level of the chlorophyll content. The relative chlorophyll content (Spad-Units) was measured in the second and third leaves of maize (results are not shown).

The SPAD-Units significantly increased in the second and third leaves of maize in all treatments compared to the control values. The relative chlorophyll content increased 5 SPAD-units in the second and third leaves of maize at the 5 ml fluid by-product treatments. This value increased with 7 SPAD-Units in the second and 5 SPAD-Units in the third leaves at the 10 ml fluid by-product treatment

Table 3. Effects of fluid by-product of biogas factory on the dry weight of shoots and roots of maize (g plant^{-1})

Treatments	Shoot (g plant^{-1})	Root (g plant^{-1})
Control	0.120 ± 0.04	0.035 ± 0.01
5 ml	0.091 ± 0.02	0.021 ± 0.01***
10 ml	0.082 ± 0.02*	0.020 ± 0.01
50 ml	0.096 ± 0.02	0.015 ± 0.00***

Conclusions

Most of the investigated elements are localized in the shoots. The fluid by-product can be suitable for replacing expensive mineral fertilizers and the by-product has an important role in the environment protection. We maintain that the fluid by-product of newly emerged biogas factories can be useful tools of suitable agriculture from environmental aspect too.

References

Allen, M. R. − Braithwait, A. − Hills, C.C.: 1997. Trace organic compounds in landfill gas at seven UK waste disposal sites. Environ Sci Technol; 31, pp. 1054-1061.

Arthur, R. − Baidoo, M. F. − Antwi, E.: 2011. Biogas as a potential renewable energy sources: A Ghanian case study. Renewable Energy 36, pp. 1510-1516.

Eklund, B. − Anderson, E. P. − Walker, B. L. − Burrows, D. B.: 1998. Characterization of landfill gas composition at the fresh kills municipial solid-waste landfill. Environ Sci Technol; 32:2233-7.

G. Michael, Über die Aufnahne und Verteilung des Magnesiums und dessen Rolle in der höheren grünen Pflanze. Z. Pflanzenernaehr. Dueng. Bodenkd.25 (1941) 65-120.

Wellinger A. − Linberg A.: 2000. Biogas upgranding and utilization-IEA Bioenergy Task, Vol. 24. Paris, France: International Energy Association.

Wyn Jones R. G. − Bradly C. J. − Speirs J.: 1979. Ionic and osmotic relations in plant cells. In 'Recent Advences in the Biochemistry of Cerals' (D.L. Laidman and R.G. Wyn Jones, eds.), 63-103. Academic Press, London.